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To: [redacted] Date: January 26, 1988

From: .R. A. Comes & R. N. Ferguson

Subject: .Operational Plan for the Sidestream Control Program

OBJECTIVE

Conduct research on sidestream smoke formation in order to understand and control three major parameters - visibility, smoke aroma and compounds reported to be irritants. Develop cigarette models with a target of 50% reduction of total sidestream smoke and evaluate these models by the end of 1990. Develop cigarette models with selective reduction in a major sidestream parameter incorporating R&D technology by the end of 1990. Integrate these results and models into the ongoing Studio product development program by the end of 1991.

STATUS AND BACKGROUND

The sidestream program has been ongoing from the product development standpoint for several years. This effort has been directed toward the establishment of defined cigarette models that meet all criteria for market place introduction as required. Potential shelf items are currently available in several configurations and at several deliveries. These potential products utilize commercially available cigarette wrappers [$Mg(OH)_2$ - Ecusta] as the primary method of sidestream smoke reduction. Subjective acceptability has been obtained by blend, flavor and filter modification.

The research aspects of the program were initiated early in 1987. They were directed toward the determination of the mechanisms by which the commercial wrappers operate, at investigations into similarities and/or differences in the chemistry of the mainstream and sidestream smoke from reduced visibility models vs suitable controls, at the structural properties of the papers and at other parameters not previously studied. The program was expanded in the third quarter of 1987 to include an "odor and irritation" study, predicated on the 1986 Report of the Surgeon General and on data generated by marketing input from Philip Morris New York personnel.

Visibility measurements are run on all models. Mass loss rate, aerosol particle size, sidestream smoke temperature, smoke particle velocity and relative particulate fraction data are generated in addition to the visibility information. Data has been obtained on the effects of blend components, on numerous commercial and experimental cigarette papers, on differences between commercially available products, on the effect of cigarette circumference and on the effects of various additives. By far, the parameter of primary importance to the control of sidestream (and mainstream) smoke is the cigarette wrapper.

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The commercial suppliers have each presented a mechanism for the successful reduction in visible sidestream smoke by the use of various additives. In simplest terms, Ecusta proposes that their $Mg(OH)_2$ wrappers encase the advancing coal leading to a reburn of the combustion products and hence an increase in gas phase components, thus yielding reduced visibility. Kimberly-Clark postulates that the surface area is the important factor influencing visibility reduction in that smoke components are trapped on the large surface area available and are then further combusted as the coal advances. They have demonstrated significant visibility reductions using papers incorporating the small particle size materials, $A\ell_2O_3$ and attapulgite clay (SiO_2). Very recently, K.C. has supplied us with fine particle size $CaCO_3$, which also demonstrates a significant reduction in visible sidestream smoke. Both of these proposed mechanisms may exert a significant influence, and in addition, evidence generated at P.M. indicates another factor may be operating as well. Very different curves are generated if plots are made of permeability vs temperature for $Mg(OH)_2$ wrappers vs conventional papers. The permeability of the $Mg(OH)_2$ wrapper appears to increase (become more porous) as the temperature increases up to the point of paper destruction. In contrast, the permeability of the conventional wrapper remains essentially constant to the destruction point. This data tends to indicate an opening of the reduced visibility paper as the temperature gradient approaches, allowing the entry of oxygen and a more complete combustion process to take place.

The commercial and experimental papers have been examined on a macro and micro scale. Light microscopy has shown differences in paper structure and "tightness" as a result of refining and changes in basis weight. Scanning electron microscopy and transmission electron microscopy have yielded important information on the structural characteristics, chemical composition and elemental distribution in papers with and without sidestream control additives. The wrappers that were most effective in reducing visible sidestream smoke appeared to have the flax fibers encased by the additive. In contrast, the conventional papers have the normal additives ($CaCO_3$ and burn control agents) randomly distributed among the fibers. However, initial microscopic examination of the recently obtained small particle size $CaCO_3$ paper shows agglomerated particles of $CaCO_3$ which do not appear to effectively cover the individual fibers. Potentially, a different mechanism is operating with this additive.

A vast literature exists on the chemistry of tobacco and of mainstream smoke. Some information on sidestream chemistry is available but it suffers from a lack of consistency in collection procedures used, a lack of uniformity in analytical techniques employed and large disparities in the data reported. Our initial efforts were directed toward designing a collection device and defining analytical procedures that would yield reproducible data at reasonable detection levels. Multiple chimney designs were investigated. Various trapping and eluting techniques were attempted. It was determined that the analysis of sidestream whole smoke generated data that was not consistent. A procedure was established, based on previous investigations for the VDC nicotine program, whereby a portion of the sidestream (or mainstream if desired) smoke from four cigarettes is trapped on a short silica gel column. The column is then serially eluted with hexane, ethyl acetate and methanol and the solvent fractions investigated by capillary gas chromatography with detection by FID, NPD and MS. This method has yielded chromatographic information that is reproducible within a given

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cigarette type and which can be compared with data from other models. The semivolatile fractions of cigarettes with and without wrappers yielding reduced visibility sidestream smoke were investigated. It was generally concluded that there were few qualitative or quantitative differences among all of the models studied. However, 300+ compounds have been identified in sidestream smoke. The compounds have been tabulated and are searchable by various means and can be individually investigated as required.

A group has been established within the Analytical Research Division to determine appropriate analytical methodology and to conduct routine analyses on certain compounds defined as irritants in the 1986 Report of the Surgeon General. Analytical procedures (TDL and ion chromatography) have been defined for determination of ammonia in mainstream and sidestream smoke. Selected cigarette models have been investigated and data reported. Additional methods are under investigation for other components.

Radiochemical capability for total distribution studies and for precursor-product investigations has been re-established. Initial investigations have been conducted on cigarettes with and without $Mg(OH)_2$ wrappers utilizing a C-38 hydrocarbon specifically labelled with ^{14}C. Differences in distribution were noted with an increased SS gas phase and a reduced SS TPM found in the low visibility models. Some very preliminary studies using neutron radiography techniques have been carried out to determine the effect of the reduced visibility wrappers on build-up of smoke condensibles behind the advancing coal. Schlieren techniques have been used to investigate the location of the thermal and visible smoke plumes. The thermal convection column appears to be located 2-3mm in front of the paper burn line for both conventional and reduced sidestream models. However, the faint smoke plume appears directly over the paper burn line in the low sidestream papers. Some related coal temperature measurements were also initiated but not completed.

Initial studies have been carried out to determine feasibility for use of specific materials to "mask" or alter sidestream odor with little or no effect on mainstream subjectives. Anethol release compounds which decompose during cigarette smoking were studied and found to have potential benefits. Glucovanillin (CR-2673) is currently being investigated. "Ashtray aroma" was addressed and progress made to define its chemical composition. The odor profile data base was greatly expanded during 1987 and this continues with the profiling of specific materials identified in sidestream smoke.

New cigarette models have been produced for evaluation. Cigarettes with different types and levels of humectant on sheet material are available for evaluation in conventional wrappers. A wrapper incorporating small particle size $CaCO_3$ and succinate anion burn additive has been prepared for investigation of visibility reduction and subjective interest. Cigarettes have been requested with unique changes (citrate inner wrap and $Mg(OH)_2$ outer wrap) to the traditional construction.

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STRATEGIES

The following section contains strategies and tactics relevant to each strategy with approximate completion dates assigned where possible.

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Three broad strategies are recommended for the Sidestream Control Program.

I. Identify and quantitate compounds which have a significant influence on sidestream smoke odor or irritation.

Tactics and Timetables:

1. Develop and apply methods to quantitate defined irritants in smoke - ammonia, formaldehyde and acrolein (aldehydes), toluene and benzene (aromatics). 4th Q 88

2. Evaluate the literature for compound irritation thresholds and identify additional reported irritants.
   a. Complete internal and external literature searches. 1st Q 88
   b. Evaluate literature searches. Evaluate potential outside contract resources, if needed. 2nd Q 88
   c. Recommend future action plan based on a and b. 3rd Q 88

3. Design acceptable "assays" for other irritants and/or materials which elicit trigeminal effects.
   a. Conduct a literature search for available irritant bioassays. Evaluate research proposal from outside resource. 2nd Q 88
   b. Initiate a collaborative study with outside resource. 3rd Q 88

4. Conduct individual compound or whole sidestream irritant evaluation using analytical & bioassay endpoints. 4th Q 88 - 4th Q 89

5. Survey components of sidestream smoke semivolatiles and gas phase using gc/ms.
   a. Develop procedures for sidestream gas phase analysis. 1st Q 88
   b. Analyze reduced sidestream and regular cigarette models using method developed in a. 2nd Q 88
   c. Initiate odor/irritation studies by constructing a GC sniffing port. 3rd Q 88
   d. Conduct ongoing sidestream smoke component identification as new models and improved techniques become available 1st Q - 4th Q 88

6. Build a smoke component library and odor data base.
   a. Order commercially available identified smoke components for odor evaluation. 1st Q 88
   b. Complete odor profile of Dravnieks mixture. 2nd Q 88
   c. Begin synthesis of non-commercially available smoke components. 1 Q 88 and continuing

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d. Odor profile smoke components. continuing

7. Design and construct an ETS chamber where subjective and quantitative odor and irritation evaluations can be made.
   a. Travel to FTR to evaluate and define chamber design and instrumentation. Initiate 650 preparation. 1st Q 88
   b. Complete 650, modify laboratory, order chamber construction materials, order long lead time instrumentation. 2nd Q 88
   c. Construct chamber and order remaining instrumentation. 3rd Q 88
   d. Complete chamber and instrumentation installation and check-out. 4th Q 88

8. Staff and put chamber into routine use and establish baseline data for defined components.
   a. Prepare a job description, interview and hire a T-2 for chamber operation. 3rd Q 88
   b. Train hired T-2 for chamber operation. 4th Q 88

9. Utilize the chamber to quantitate initial levels and establish half-life data for selected irritants. 1989

10. Utilize the chamber to establish meaningful baseline odor evaluations using reference odorants to compare with identified smoke components. 1989

11. Define, purchase and put into use radiochemical smoke formation instrumentation capable of supporting precursor/product studies.
   a. Set up and place in operation radio/GC instrumentation. 1st Q 88
   b. Develop and apply radio/GC methodology to sidestream semivolatiles and gas phase on reduced visibility and control cigarettes. 3rd Q 88
   c. Complete set up of solenoid activated valve assembly (SAVA). 1st Q 88
   d. Apply SAVA technique to radiolabelled cigarettes. 2nd Q 88
   e. Modify total recovery smoking machine for sidestream collection in solution (non-destructive). 4th Q 88

12. Apply the radiochemical capability to:
   a. glycerine;
      1. Complete total radioactivity distribution studies on $Mg(OH)_2$ cigarettes and suitable controls. 1st Q 88
      2. Spray additional filler with ^{14}C-glycerine and prepare additional labelled cigarettes. 1st Q 88

   nicotine;
      1. Prepare radiolabelled cigarettes. 3rd Q 88

   hydrocarbons;
      1. Conduct ^{14}C-smoke studies. 4th Q 88

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b. odor and/or irritant precursors 1989

13. Identify smoke components principally associated with cigarette butt odor.
    a. Complete survey of brand and filler types. 1st Q 88
    b. Fractionate volatiles to localize characteristic odor. 1st Q 88
    c. Conduct analytical and sensory evaluation of major components of butt odor. 2nd Q 88
    d. Continue evaluation with minor components. 4th Q 88

14. Evaluate origin and possible control of compounds associated with cigarette butt odor. 1989

15. Determine if a correlation exists between components associated with lingering sidestream odor in rooms and those implicated in cigarette butt odor. 1989

16. Conduct quantitative and subjective research on vanillin release systems designed to mask sidestream odor.
    a. Select analytical method of quantitate vanillin in smoke. 2/88
    b. Evaluate method for vanillin in smoke using glucovanillin as model compound. 2nd Q 88
    c. Conduct subjective evaluations to determine acceptable application level. Prepare paper treated models at this level. 2nd Q 88
    d. Conduct analytical and subjective evaluations of chosen models. 3rd Q 88

17. Develop additional subjectively acceptable masking odors for sidestream aroma control.
    a. Based on results of glucovanillin study (16) and on input from consumer evaluation (19), initiate studies on other compounds to mask sidestream odor. 4th Q 88

18. Evaluate new product ideas with consumers - internal and/or external to PM (i.e. acceptable flavors to mask sidestream aroma). 1989

19. Use consumer evaluation methods to better define product opportunities in the general area of sidestream odor. 3rd Q 88

20. Apply developed methods for irritants/odors to evaluate Studio models or models for PM proprietary products as needed. Ongoing

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II. **Determine the mechanisms by which cigarette paper or other components of cigarette construction influence the visibility and chemistry of sidestream smoke.**

Tactics and Timetables:

1. Use the visibility measurement system to continue studies on visibility and related aspects of the smoke aerosol from selected models.
   a. Conduct visibility measurements on humectant models. 1st Q 88
   b. Conduct visibility measurements on models for FTR evaluation. 1st Q 88

2. Use the paper permeability system to evaluate the performance of new commercial models ($CaCO_3$) and P.M. designed models. Thru 1st half 1989

3. Conduct Schleiren and/or high speed photography studies on burning cigarettes; as need arises based on visibility data. Not staffed at present

4. Conduct coal temperature studies on models with significantly different visibilities. Not staffed

5. Establish an aerosol research effort to investigate composition versus aerosol particle size for sidestream smoke and study the effects of wrapper construction upon these parameters. Not staffed

6. Provide priority evaluation of Kimberly-Clark high surface area $CaCO_3$ paper since it may soon be a commercial alternative to the Ecusta $Mg(OH)_2$ wrapper.
   a. Conduct GC/MS semivolatile scans of $CaCO_3$ treated paper vs $Mg(OH)_2$ control. 1st Q 88

7. Set up a group to coordinate and conduct fundamental research studies of interest to PM on cigarette wrappers with emphasis on reduced sidestream effects. Initiate by 4th Q 88

8. Establish a hand sheet making capability to facilitate the study of new paper concepts.
   a. Order equipment and prepare facility 1st Q 88
   b. Set up equipment, training, begin casting sheets 2nd Q 88

9. Conduct microscopic examinations of various papers to relate structural parameters to sidestream visibility effects. 1st Q 1989

10. Determine the effects of various models with 50% or more visibility reduction on other parameters of interest, specifically those related to odor and irritation. 1989

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11. Investigate build-up of condensibles for normal and reduced visibility models.
    a. Install and place in operation the new image processing equipment. 1st Q 88
    b. Initiate studies at UVa with the image processor. 2nd Q 88
    c. Compare reduced visibility and control cigarette models using the image processor. 3rd Q 88
    d. Define models to investigate condensibles build-up. 4th Q 88

12. Use contract resources to study polar/non-polar nucleation effects on clustering and aerosol growth.
    a. Identify relevant areas of sidestream research for contract resources. 1st Q 88
    b. Based on program progress, decide on continuation of evaluations. 4th Q 88

13. Re-evaluate the contribution of conventional construction parameters, other than the wrapper, to sidestream visibility and chemical composition. 1989

14. Evaluate the contribution of major current additives, e.g. humectants, and of cigarette compatible salts and inorganics to visibility. 4th Q 88

III. Modify cigarettes to demonstrate reduction in total sidestream or in selected aspects or components of sidestream smoke.

Tactics and Timetables:

1. Use multiple sidestream endpoints to evaluate papers available from commercial sources.

    a. general reduction of aerosol and/or gas phase. 3rd Q 88
    b. selective reduction of specific components. 1st Q 89

2. Evaluate potential proprietary paper processes such as various inorganic additives using handsheet/handmade screening approach.

    a. general reduction of aerosol and/or gas phase. 1st Q 89
    b. selective reduction of specific components. 2nd Q 89

3. Evaluate other wrapper concepts - coated paper, embossed paper, carbon lined paper, organic polymer wrapper - with respect to:
    a. general reduction of aerosol and/or gas phase. 1st Q 89

    b. selective reduction of specific components. 3rd Q 89

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4. Re-evaluate possible use of non-tobacco smoking materials, tobacco derived NTSM, extenders, etc. admixed with tobacco on:

   a. general reduction of aerosol and/or gas phase. 4th Q 89

   b. selective reduction of specific components. 1990

5. Evaluate low density rods with optimized burn rate, binder, etc. on:

   a. general reduction of aerosol and/or gas phase. 3rd Q 88

   b. selective reduction of specific components. 1st Q 89

6. Conduct a research study of core/periphery differences in cigarettes as potential for either general or selective sidestream reduction. 1989

7. Evaluate tobacco derived carbon as a blend component to reduce sidestream. 4th Q 88

8. Extend favorable models from above studies to ETS evaluation and evaluate mainstream subjectives. 1990

9. Evaluate production parameters, costs, materials availability and smoking and health aspects of prime candidates. 1990

10. Recommend models for Studio use based on results from 9 (above). early 1991

RESOURCE ALLOCATION

1. How are personnel to be allocated?

The attached table indicates the needs of this program. These are individuals directly involved in important aspects of the program. Note that half the resources are outside the Division and are subject to many other needs, based on experience from 1987.

This program cannot make any progress without considerable cooperation among several divisions. The most critical areas for resource allocation outside of Chemical Research are:

Analytical Research	-	Irritant analysis methods, microscopy, odor fractionation identification
Product Evaluation	-	Consumer research, subjective evaluation, odor profile
Flavor Development	-	New paper and construction concepts and subjective evaluation Sidestream odor masking
Cigarette Technology	-	Hand cast paper facility and staffing Studio coordination, smoke aroma panel

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2. Do you have enough people?

This question will only be addressed with respect to the Chemical Research Division. In developing these plans it is clear that additional research needs to be done on the question of sidestream aerosol particle size and composition. A Research Scientist with an interest in the chemistry of this aerosol and methods to control this parameter would be of great value, especially in conjunction with Dr. Jenkins and the radiochemistry group. We would need a researcher with a Ph.D. and direct experience in this field. Such an individual would address areas such as Strategy II, tactics 3,4,5 which had been in long range plans for Dr. McRae.

A second priority is a technician (T-2) to address multiple needs within the smoke and radiochemistry groups. The need will be especially critical late in the year as research studies using the ETS chamber begin.

As a final note, an enlarged group of volunteers must be located and encouraged to participate in various odor evaluation studies.

3. Do you have the right people?

Within Chemical Research the answer is yes, but see the personnel needs listed above within the Division. Outside the Division the right people are in place provided the allocations requested can be met. Note especially that "man years" are not interchangeable. For example, Mr. Keritsis, Dr. Kallianos, and Mr. Pfleuger are resources in Flavor Development and cannot be replaced by the equivalent time commitment of other individuals.

4. Do you need special equipment, etc.?

A considerable impact will occur from direct equipment/facilities needs of the program. Two bays on T-7 will be used to set up the ETS chamber and associated equipment. This requires a considerable capital outlay, facilities renovation, etc. The establishment of a hand sheet preparation facility by Cigarette Technology will require special equipment and some space. The tactics to begin paper research related to sidestream will initially make use of the staff/expertise/facilities of project 1758 in Chemical Research. Aerosol chemistry would have little impact <u>in 1988</u> since most work would be associated with outside contracts. (See item 5 below).

5. Do you need outside expertise?

The answer to this question is a strong affirmative.

University of Virginia	-	Neutron radiography and aerosol balance studies
University of Washington	-	Aerosol balance
Colorado State University	-	Polar/non-polar clustering and possible reactions in aerosols
VPI & SU	-	Paper chemistry
Herty Foundation	-	Research paper production with confidentiality agreement

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Duke University	-	Possible bioassay and research on irritants or trigeminal agents
VCU	-	Resource for synthesis of selected smoke components
Dartmouth	-	Resource for possible microscopy studies of cigarette papers, commercial or proprietary

In addition, both major paper suppliers, Ecusta and Kimberly Clark, are being considered as resources in certain areas of the program.

IMPACT ON OTHER AREAS

Within R&D, a number of groups will be impacted by the planned efforts in the Sidestream Control Program. The listed impacts are in addition to direct resources for the program listed in the previous section.

Administrative Services	-	Assistance needed for lab modifications chamber construction and cast sheet facility.
Analytical Research	-	Wrapper and cigarette samples will need routine analytical support.
Cigarette Technology	-	Support needed for hand sheet casting and paper coating.
Cigarette Testing	-	Extensive support needed for Studio program and some for a few research models also.
Computer Applications	-	Implementation of MDL program will benefit sidestream components/odor studies. PE LIMS system.
Technical Information Section	-	Literature assistance/retrieval needed on irritants.
Tobacco Fundamentals	-	Models from low density rod program. Support from modified smoking materials area for Keritsis trials.
Tobacco Materials Division	-	Additives to recon will need small scale preparation.
Tobacco Services	-	Both primary and make pack areas of semiworks will need to support small model demand from research program and a number of models from Studio area (Paul Gauvin).

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IMPACTS ON OTHER DEPARTMENTS

New York Marketing Department - Program needs input from consumer studies of concepts and actual models.

FTR - Chamber associated studies on USA models will continue for all of 1988 until USA chamber is on line.

EEP - Limited support needed in training and safety aspects of new facilities - ETS chamber, etc.

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TABLE I

OPERATION PLANS 1988 - RESOURCES

BY DIVISION - MAN YEARS

	CR	ARD	ASD	BCR	C.TEC	DEV.E	FL.DEV	PRD	PED	T.FUND	T.MAT	KEY WORDS
STRATEGY I.												
Tactic 1	0.2	2.6										Irritant methods
Tactic 2	0.1											Additional irritants
Tactic 3	0.2											Contract research,irritant assay
Tactic 5	1.6											Components survey
Tactic 6	1.5								1.0			Component odor profile
Tactic 7	1.1	0.1	0.2	0.1	0.2	0.2			0.5			ETS chamber
Tactic 8	0.3											ETS staffing
Tactic 11	2.0											Radiochemical methods
Tactic 12	2.3											Contract research,smoke formation
Tactic 13	0.7	1.0							0.2			Butt odor
Tactic 16	0.5				0.1		0.2		0.2			Vanillin release
Tactic 17	0.2											SS Odor masking
Tactic 18					0.3				0.5			Consumer study
Tactic 19									0.2			N.Y. Marketing,consumer preference
STRATEGY II.												
Tactic 1	0.3											Visibility measure
Tactic 2								0.5				Permeability system
Tactic 3												Aerosol scientist,optical study
Tactic 4												Personnel required,coal temperature
Tactic 5												Aerosol scientist,aerosol chemistry
Tactic 6	0.4	0.3			0.3			0.1				K.C. wrapper
Tactic 7	1.1	0.5										Paper-fundamental studies
Tactic 8	0.2				0.1							Hand sheet capability
Tactic 9		1.0						0.4				Microscopy
Tactic 11	0.2											Condensibles
Tactic 12	0.2											Contract research,nucleation/aerosol
Tactic 14	0.2											Additives contribution
STRATEGY III.												
Tactic 1	0.1	0.1			0.1							Commercial papers
Tactic 2	0.1	0.1			0.1		0.3					Proprietary wrappers
Tactic 3		0.1			0.1		0.3					New wrapper concepts
Tactic 5	0.2	0.1					0.1			0.5		Low density rod
Tactic 7	0.1	0.1									0.5	Tobacco derived carbon

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TABLE II
Operation Plans 1988 - Man Years
Chemical Research - By Grade

	14	13	12	11	9.0	7.0	T-4	T-2
Strategy I.								
Tactic 1			0.1	0.1				
Tactic 2			0.1					
Tactic 3		0.2						
Tactic 5			0.1	1.0	0.2	0.3		
Tactic 6			0.2	1.2	0.1			
Tactic 7	0.1		0.3	0.1	0.2	0.4		
Tactic 8								0.3
Tactic 11	0.1			1.0	0.5	0.4		
Tactic 12	0.1			1.0	0.5	0.4	0.3	
Tactic 13			0.3	0.2	0.1	0.1		
Tactic 16			0.3	0.1	0.1			
Tactic 17			0.2					
Strategy II.								
Tactic 1			0.1			0.2		
Tactic 6	0.1		0.1	0.1		0.1		
Tactic 7	0.1		0.5	0.4			0.1	
Tactic 8			0.1	0.1				
Tactic 11	0.2							
Tactic 12	0.1	0.1						
Tactic 14	0.1					0.1		
Strategy III.								
Tactic 1			0.1					
Tactic 2	0.1							
Tactic 5				0.2				
Tactic 7					0.1			
TOTAL	1.0	0.3	2.5	5.5	1.8	2.0	0.4	0.3

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Tomorrow

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